The Effects of Physical Activity on Executive Function Tasks in Children With FASD

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Introduction

- Fetal Alcohol Spectrum Disorder (FASD) is an umbrella term that covers a range of related birth defects resulting from prenatal alcohol exposure.
- FASD affects approximately one percent of the Canadian population and is the leading known cause of preventable developmental disability in Canada with an estimated annual cost of $7.6 billion to support remedial medical, educational and social costs.
- Children with FASD have multiple neurological and behavioral impairments, including deficits in cognition and executive functioning which often manifest as functional challenges in daily living in the home, school, and community.
- Executive function is a term that encompasses skills necessary for novel, goal-directed, and complex behavior including self-regulation, problem solving, and daily organization.
- Specific neurological impairments resulting from FASD involve memory, attention, visual-spatial ability, declarative learning, planning, cognitive flexibility, processing speed, and language development delays.
- One intervention strategy that appears to be promising for improving multiple areas in the lives of children with FASD is physical activity.
- Evidence from both animal models and human studies indicate that exercise can increase the learning and memory capacity of the brain, possibly through increases in brain-derived neurotrophic factor (BDNF), a chemical that helps brain cells thrive and survive.
- FAST Club is a physical activity intervention program which aims to increase neuropsychological functioning in children with FASD.

Hypothesis

- Children with FASD who participate in FAST Club will improve in aspects of executive functioning when compared to control children, as assessed by the code transmission and self ordered pointing tasks.

Test of Everyday Attention for Children (TEA-Ch)

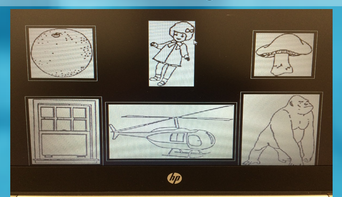
- The capacity to sustain attention provides the basis for many cognitive and neuropsychological functions.
- The TEA-Ch is a standardized and normed (ages 6-16) clinical battery of tests for children that allows for relative assessment across different capacities of attention.
- Subtests of the TEA-Ch are reported to assess various components of attention such as focused (selective) attention, sustained attention, and attentional control/switching.

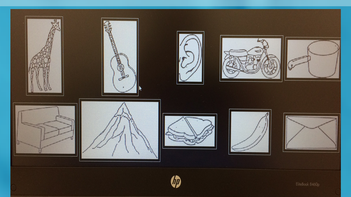
TEA-Ch Subtest: Code Transmission

- The Code Transmission subtest is considered an auditory vigilance measure of sustained attention in both normal and clinical populations.
- The task requires children to monitor a stream of monotonous digits (presented at a rate of one every 2 seconds) for the occurrence of a particular repeat target sequence (e.g. 5 5) and then to report the digit that occurred immediately before the target.
- Following a practice sequence, 40 targets are presented over the 12 minute duration of the task.
- The number of correct targets identified out of 40 is then converted into an age normed standard score. The standard score scale ranges from 0 to 19.

Self Ordered Point Task: A Test of Working Memory

- The SOPT is a test of working memory that is sensitive to pathology of the frontal lobe. The task requires individuals to initiate and execute a sequence of responses, maintain a cognitive record of their responses, and monitor their performance.
- SOPT scores are correlated with measures of working memory, verbal learning, visuospatial ability, and other select aspects of executive functioning (i.e., strategy utilization and planning).
- The SOPT has five conditions that progressively get more complex and each condition has 2 trials.
- The five conditions differ by the number of common pictures that are to be selected (4, 6, 8, 10 and 12 picture conditions). In each condition, participants are instructed to select a picture on the screen. Once selected, all the pictures on the screen are rearranged and participants must select another picture without clicking on one they had touched previously until all pictures present on the screen had been selected.
- Selecting the same picture two or more times is scored as an error by the program and the total number of errors across all trials is averaged to assess SOPT performance.



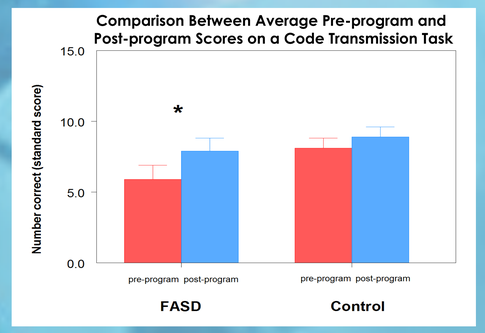


Methods

- 13 FASD children and 10 age matched controls (all aged 7-12 years) participated in a case control design study that investigated the effects of the FAST Club intervention on executive function in children with FASD. All study participants were involved in pre and post-program neuropsychological testing. Two of the tests were the code transmission subtest of the TEA-Ch battery and the SOPT.
- The FAST club intervention was held for 1 hour bi-weekly for a period of 12 weeks. During each session, FASD children were required to participate in stations that were designed to work on specific physical attributes while maintaining a moderate level of exercise intensity (as measured by heart rate monitors). There were 5 stations in total (Bilateral Coordination, Upper-Limb Coordination, Strength, Agility, and Balance). The children cycled through 3 stations each session, with the final component of each session being work on a self chosen phsyical activity.
- The control children did not participate in the FAST Club intervention and were used to control for test-retest effects.
- During the Code Transmission task, participants and test administrators listened to the 12 minute recording in a volume controlled space through a set of headphones. Participants were required to indicate to testers when they heard the number 5 repeated consecutively (the target sequence) and to report the digit that came before the repeated 5s.
- The SOPT was conducted using a laptop computer. Children used the curser to select the pictures and the data was saved automatically to the desktop.
- Significant differences between Control and FASD children and pre and post-test scores were analyzed by t-tests. Values are presented as the mean ± SEM.

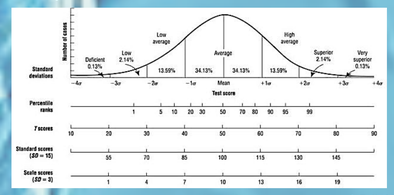
Code Transmission Results

Figure 1. Results of standard scores for total correct responses on the code transmission task



- Pre-program total number of correct responses showed a significant difference between the FASD and control children (p = 0.034)
- FASD children's standard score significantly increased after FAST Club compared to pre-program levels (*p = 0.027)

Figure 2. Visual Depiction of Standard Score Clinical Relevance

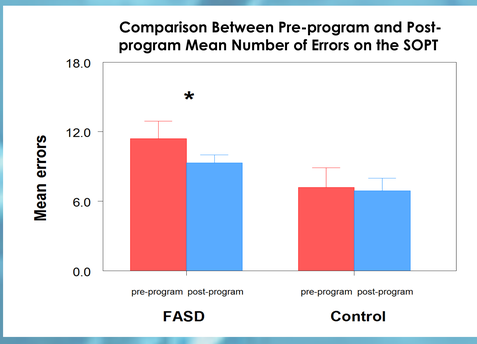


Scaled Score	Percentile Rank	Code Transmission Classification
19	99.9	
18	99.6	
17	98.6	Above expected level
16	97.7	
15	95	
14	91	
13	84	
12	75	At expected level
11	63	
10	50	
9	37	
8	25	
7	16	
6	9	Borderline Impairment
5	5	
4	2.3	Below expected level
3	1.4	
2	0.4	Well below expected level
1	0.1	

- FASD children had a mean pre-program standard score of 5.9 ± 2.8 SD and a mean post-program score of 7.9 ± 2.6 on a 19 point scale.

Self Ordered Pointing Task Results

Figure 3. Pre-program and post-program mean number of errors on the SOPT



- The mean number of pre-program errors committed by FASD children was significantly greater than age matched controls (*p = 0.033)
- The mean number of post-program errors committed by FASD children showed a trend to decrease following FAST Club compared to pre-program levels (*p = 0.089). Trend = (p = 0.05 – 0.10)

Discussion

Code Transmission

- FASD children performed significantly worse on the pre-program test than control children, indicating poorer sustained attention. The FASD children's mean pre-program range was considered to be below the age normative level of ability. However, after the FAST Club intervention, the mean score was at the age expected level indicating an improvement in ability to sustain attention in the FASD children.
- Control participants had no significant change from the pre to post-test and the range of control scores was consistently considered to be at the expected level for their age.
- These findings indicate that physical activity may mitigate some of the effects of prenatal alcohol exposure on sustained attention and are consistent with previous studies that have investigated the effects of physical activity on sustained attention in typically developing children.

Self Ordered Pointing Task

- FASD children committed significantly more errors than control children on the SOPT during pre-program testing, indicating impaired working memory.
- The pre-program vs post-program results did not reach significance for FASD children. However, the mean number of errors committed by the FASD children was trending toward a significant result and was likely affected by issues of participant dropout on this specific test.
- Mean errors committed by FASD children post-program were not significantly different from control children.
- Taken together, these results suggest that physical activity has a beneficial effect on working memory in children with FASD.

Conclusions

- Overall, these outcomes support the idea that prenatal alcohol consumption impairs sustained attention and working memory which are important aspects of executive functioning in children.
- Physical activity appears to improve sustained attention and working memory in children with an FASD diagnosis. Interventions for FASD children should continue to look to increase the level of physical activity that FASD children participate in as it's benefits may have far reaching impacts in their lives.